Missouri Department of Natural Resources
Water Pollution Control Program

Total Maximum Daily Loads (TMDLs)

for

Cedar Creek
Boone and Callaway Counties, Missouri

Completed December 26, 2000
Approved January 30, 2001

Two Total Maximum Daily Loads (TMDLs)
For Cedar Creek
Pollutants: Low pH and Sulfate

Name: Cedar Creek

Location: Boone-Callaway County line north of Interstate 70, Missouri

Hydrologic Unit Code (HUC): 10300102-190001

Water Body Identification (WBID): 0737

Missouri Stream Class: The impaired segment is a Class C stream[1]

Beneficial uses: Livestock and Wildlife Watering, Protection of Warm Water Aquatic Life[2] and Human Health-Fish Consumption

Size of Impaired Segment: 2 miles for pH and 3 miles for sulfate

Legal Description of Impaired Segment: The upstream end of this segment is in the center of Section 15, T49N, R11W and the downstream end is in the N 1/2 of section 34, T49N, R11W

Pollutants: Low pH and Sulfate

Pollutant Source: Upper Cedar Creek coal mine area

TMDL Priority Ranking: High

1. Background and Water Quality Problems

Cedar Creek originates in northeastern Boone County. The first three miles are unclassified and are wholly contained within Boone County. The next 33 miles of stream are Class C and form a portion of the Boone-Callaway county line. The impaired section of Cedar Creek begins about 2.5 miles downstream from where Cedar Creek becomes a Class C stream, a point which lies near the center of the Cedar Creek mined land area. Legals for the upstream and downstream end of the impaired segment are given above.

[1] Class C streams may cease to flow in dry periods but maintain permanent pools that support aquatic life. See 10 CSR 20-7.031(1)(F)

[2] This portion of Cedar Creek and its watershed is developed in glacial till overlying Pennsylvanian aged bedrock and is considered a prairie stream. Missouri's Water Quality Standards allow prairie type Class C streams to be classified as "limited" warmwater fisheries.

Frequent violations of Missouri's Water Quality Standards for pH and sulfate have occurred in Cedar Creek. The most severe episodes of acidity (low pH) and high levels of sulfate are during low flow conditions when there is little or no upstream flow to dilute the drainage from these abandoned mine lands. For this reason the design flow condition for this TMDL is the 7Q10 low flow (the lowest average flow for seven consecutive days with a recurrence interval of ten years).

Acid mine drainage forms when sulfide minerals in rocks are exposed to oxidizing conditions. There are many types of sulfide minerals. Pyrite and marcasite are the iron sulfides common in coal regions. These minerals make up a large amount of the overburden that was found at the Upper Cedar Creek Project. Upon exposure to oxidizing conditions, sulfide minerals oxidize in the presence of water and oxygen to form highly acidic (low pH), iron- and sulfate-rich drainage. The sulfate produced by this weathering may persist for a long time in water. Both low pH and high levels of sulfate are harmful to aquatic life.

A large area (approximately 1200 acres) on Upper Cedar Creek straddling the Boone-Callaway county line just north of Interstate 70 was strip-mined for coal by the Marriot-Reed Coal Company between 1941 and 1962. This is referred to as the Upper Cedar Creek Abandoned Mined Land (AML) Area. It lies in parts of Sections 12, 14, 15, 16, 21, 22 and 23 of T49N, R11W. Most of this area lies west of Cedar Creek and it drains primarily into Cedar Creek via a shallow valley in Section 15. Multiple seeps of contaminated water from this area continually entered Cedar Creek in the upstream-most half mile of the impaired portion. This seriously degraded 14 miles of the creek, effectively eliminating (and preventing the reestablishment of) fish and most other forms of aquatic life from the affected area. On 27 occasions from 1941 and 1979, thunderstorms centered over these mined lands. These storms flooded pits of acid water, forcing them to overflow into Cedar Creek. This caused fish kills in downstream sections of Cedar Creek far below the normally affected section of stream. On several of these occasions, all of the fish were killed within the 44 miles of Cedar Creek between the mined lands and the Missouri River.

From 1982 to 1990, at a cost of $4.7 million, this area was reclaimed by the Missouri Department of Natural Resources (MDNR). The reclamation of these mined lands represents one of the most effective water pollution abatement projects in the state's history. It was accomplished mainly by re-contouring the surface of the land, eliminating many acid ponds, burying acid-forming spoils and establishing permanent vegetation. In areas of concentrated coal wastes, a thick layer of lime was applied prior to the placement of topsoil to help neutralize the acid-forming materials underneath. Following this reclamation project, fish and other aquatic life returned to almost all of the previously polluted 14 miles of stream and since the reclamation there have been no fish kills. Pre- and Post-reclamation water quality data are found in Appendix C. Post-reclamation data shows that portions of Cedar Creek within 3.5 miles[3] downstream of this AML still occasionally fall below Missouri's 6.5 minimum pH standard. Three miles of this segment are on the 303(d) list for exceeding the state standards for sulfate. However, the Post-reclamation data does not show a single sulfate exceedence. In this data there are four sampling times where the specific conductivity was over 2000 µS/cm (which indicates the sulfate-plus-chloride standard is probably being exceeded), but no sulfate data was collected at these times. Continued monitoring will clarify this

[3] While the 1998 303d list shows two miles of Cedar Creek affected by low pH from this source area, the data shows that 3.5 miles are actually affected. Adding one-half mile for a margin of safety, the size of the impairment will be corrected to four miles on the next 303d list.

issue. Meanwhile, the current reclamation project being done on these lands to address the pH violation will further decrease sulfate contamination.

2. Description of the Applicable Water Quality Standards and Numeric Water Quality Target

Designated Uses:
The designated uses of Cedar Creek, WBID 737, are Livestock and Wildlife Watering, Protection of Warm Water Aquatic Life and Human Health-Fish Consumption. The Limited Warm Water Fishery classification applies to this prairie stream (See footnote 2 on the previous page). The stream classifications and designated uses may be found at 10 CSR20-7.031(1)(C) and Table H.

Anti-degradation policy:
Missouri's water quality standards include the EPA "three-tiered" approach to anti-degradation, and may be found at 10 CSR 20-7.031(2).

Tier I defines baseline conditions for all waters -- it requires that existing beneficial uses are protected. TMDLs would normally be based on this tier, assuring that numeric criteria (such as dissolved oxygen, ammonia) are met to protect uses.

Tier II requires no degradation of high-quality waters, unless limited lowering of quality is shown to be necessary for "economic and social development". A clear implementation policy for this tier has not been developed, although if sufficient data on high-quality waters are available, TMDLs could be based on maintaining existing conditions, rather than the minimal tier I criteria.

Tier III (the most stringent tier) applies to waters designated in the water quality standards as outstanding state and national resource waters; Tier III requires no degradation under any conditions. Management may require no discharge or prohibition of certain polluting activities. TMDLs would need to assure no measurable increase in pollutant loading.

This TMDL will result in the protection of existing beneficial uses, which conforms to Missouri's Tier I anti-degradation policy.

Specific Criteria:

pH Standards:
Missouri's Water Quality Standards (WQS), 10 CSR20-7.031 Section (4)(E), states that water contaminants shall not cause pH to be outside of the range of 6.5-9.0 Standard Units (SU).

Sulfate Standards:
Sulfate and chloride are linked together in the WQS. Section (4)(L)1 concerns streams with 7Q10 low flow of less than one cubic foot per second (cfs). Here it states that the concentration of chloride plus sulfate shall not exceed 1000 milligrams per liter (mg/L) for protection of aquatic life.

Mixing Zone:
Because the AML area is a diffuse nonpoint source, mixing zone allowances will not apply to this TMDL recommendation.

Numeric Water Quality Target:
As discussed in the Margin of Safety (Section 6), the pH criterion alone may not provide sufficient assurance that the proper pH range will be maintained in Cedar Creek. This is due to possible latent acidity. As a result, net alkalinity is added as a second numeric water quality target. To assure that the pH water quality standard is met and maintained in Cedar Creek, Missouri chooses the net alkalinity target to be 60 mg/L or more. Further, Missouri chooses the standards for pH (6.5-9.0 SU) and sulfate (combined sulfate plus chloride equal to 1000 mg/L) as the endpoints for these parameters.

3. Loading Capacity

The Loading Capacity (LC) is the greatest amount of pollutant loading that a stream can assimilate without becoming impaired. It is equal to the sum of the Load Allocation (LA), the Wasteload Allocation (WLA) and the Margin of Safety (MOS). Since this is a nonpoint pollutant source, no single design flow can be used and thus TMDL targets cannot be mass-based. Expressed as the concentration in the abandoned mine drainage, the concentration-equivalent load capacity is a pH of 6.5-9.0 SU (the state water quality standard) and a net alkalinity of 60 mg/L or more. For sulfate, load capacity is the combined sulfate plus chloride standard of 1000 mg/L. Neither the pH nor the concentrations used as the numeric TMDL endpoints can be summed as Load Allocations (LAs) + Wasteload Allocations (WLAs) + Margin of Safety (MOS).

4. Load Allocations (Nonpoint Source Load)

Load Allocation (LA) is the maximum allowable amount of the pollutant that can be assigned to nonpoint sources. Since the Load Capacity for Cedar Creek is expressed as concentration, the Load Allocation (allowing for a margin of safety) will be as follows: 6.5-9.0 SU for pH and 900 mg/L combined sulfate and chloride.

5. Wasteload Allocation (Point Source Load)

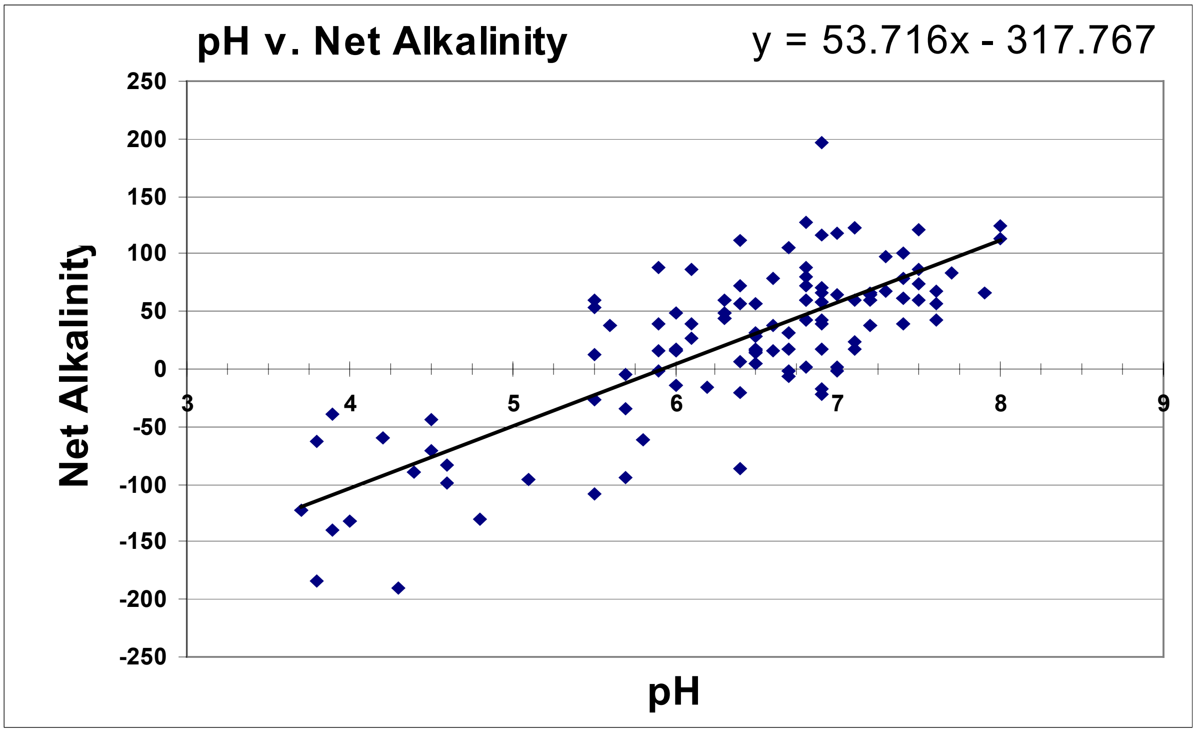
The Wasteload Allocation (WLA) is the maximum allowable amount of the pollutant that can be assigned to point sources. There are presently no point sources discharging to the affected segment of Cedar Creek. Missouri chooses the mass-WLA of zero for both acid and sulfate.

6. Margin of Safety (MOS)

MOS for pH:
Net alkalinity is a measurable characteristic of the water in Cedar Creek that may be linked to the pH water quality criterion. Net alkalinity, as used here, is defined as the total alkalinity (titrated to the pH 4.5 endpoint) minus the total acidity (titrated to the pH 8.3 endpoint). The two analyses are more fully discussed in Standard Methods for the Examination of Water and Wastewater, and both have units of mg/L as $CaCO_3$ (calcium carbonate).

Figure 1 shows the relationship between pH and net alkalinity in Cedar Creek, and the data is given in Table 1. This data spans a number of years, seasons, flows and sampling locations, and includes both pre- and post-reclamation data. As a result, this data is representative of all the conditions that may reasonably be expected to occur in Cedar Creek, and should be sufficient to construct a reasonable model of the behavior of the pH and net alkalinity in Cedar Creek.

Figure 1. The Relationship of pH and Net Alkalinity in Cedar Creek, Callaway County, Missouri.



A linear regression was plotted for pH v. net alkalinity (Figure 1). Using this regression analysis, the predicted net alkalinity for a pH of 6.5, with a confidence interval of 90 percent, would be 31mg/L net alkalinity $\pm$ 29 mg/L net alkalinity. Choosing the upper confidence limit of 60 mg/L net alkalinity as an instream target should insure adequate buffering to prevent instream pH values dropping below 6.5. This requirement of 60 mg/L net alkalinity is proposed as a Margin of Safety (MOS) for pH.

In Table 1, the data for pH in Cedar Creek is shown with its corresponding net alkalinity. The pH has been ordered from lowest to highest.

Table 1. The Relationship between Net Alkalinity and pH in Cedar Creek

pH	Alk	pH	Alk	pH	Alk
3.7	-122	6.3	60	6.9	66
3.8	-184	6.4	-20	6.9	70
3.8	-63	6.4	-86	7	-1
3.9	-140	6.4	112	7	118
3.9	-40	6.4	56	7	2
4	-132	6.4	7	7	64
4.2	-60	6.4	72	7.1	122
4.3	-190	6.5	14	7.1	122
4.4	-89	6.5	16	7.1	18
4.5	-44	6.5	18	7.1	24
4.5	-70	6.5	28	7.1	60
4.6	-84	6.5	32	7.2	37
4.6	-99	6.5	4	7.2	60
4.8	-130	6.5	56	7.2	64
5.1	-96	6.6	16	7.2	66
5.5	-108	6.6	38	7.3	68
5.5	-27	6.6	78	7.3	97
5.5	13	6.7	-1	7.4	100
5.5	53	6.7	-6	7.4	40
5.5	60	6.7	106	7.4	61
5.6	37	6.7	18	7.4	61
5.7	-34	6.7	32	7.4	78
5.7	-4	6.8	128	7.5	121
5.7	-94	6.8	2	7.5	60
5.8	-62	6.8	42	7.5	74
5.9	-2	6.8	42	7.5	87
5.9	16	6.8	60	7.6	43
5.9	40	6.8	60	7.6	56
5.9	88	6.8	72	7.6	68
6	-14	6.8	80	7.7	84
6	16	6.8	88	7.9	66
6	16	6.9	-18	8	113
6	18	6.9	-22	8	125
6	48	6.9	116		
6.1	27	6.9	18		
6.1	40	6.9	196		
6.1	86	6.9	40		
6.2	-16	6.9	42		
6.3	44	6.9	58		
6.3	48	6.9	58		

Alk = Net Alkalinity in mg/L $CaCO_3$

MOS for Sulfate:
There was insufficient sulfate and chloride data and other information to establish the uncertainty in Missouri's knowledge of the link between the allocation and the water quality of this creek. As a result, a margin of safety (MOS) equal to a 10% reduction of the load capacity was selected. Thus 100 mg/L sulfate plus chloride is the MOS for Cedar Creek. If future monitoring indicates that applicable water quality standards are exceeded for this waterbody, then the TMDL will be reopened, and the MOS will be re-evaluated based on more data and other information.

7. Seasonal variation

The water quality data collected to this point represents all seasons but is inadequate to characterize the seasonality of this water quality problem. The primary processes involved in the formation of acid water and the oxidation of sulfide are not significantly impacted by differences in air and water temperatures associated with seasonal change.

Because rainfall is seasonal in Missouri, the volume of runoff and seepage should be less in summer and autumn, which is typically the driest portion of the year. Looking at the limited available data (see post-reclamation data in Appendix C), the flow in Cedar Creek downstream of the AML varied from 0 to 8 cfs, with the highest flows in July and the lowest flows in August through October. In the absence of adequate data, best professional judgement would indicate that the highest instream acidities probably occur in a few isolated pools in Cedar Creek near the areas of maximum seepage (center of Section 15) during the driest weather. At this time, possibly only 0.1 to 0.2 miles of stream are affected. Under wetter conditions, there is sufficient flow from the mined area to cause surface flow in Cedar Creek but not enough rainfall to produce flow in Cedar Creek upstream of the mined area. In this case, instream acidity problems are less severe in terms of pH, but are still a problem. This impairment reaches its greatest extent 3.5 to 4 miles downstream.

Missouri has considered seasonal variation. Missouri standards do not distinguish between summer and winter for sulfate and pH. The allocations in this TMDL apply year round.

8. Monitoring Plan for TMDLs Developed Under the Phased Approach

Since these are phased TMDLs, MDNR has entered into a contract with the US Geological Survey, Biological Resources Division, to conduct a pre- and post-reclamation water quality study of Cedar Creek. USGS will sample 12 sites every two months for pH, alkalinity, hardness, conductivity, temperature, DO and turbidity. Once a year, they will sample for metals (Mn, Fe, Zn, Al, Cd, Cu and Ni), benthic macroinvertebrates, leaf decomposition and physical habitat. The pre-reclamation survey began in 1999. The post-reclamation survey will begin the year after the additional reclamation measures on the mined lands in this area are completed. In addition, MDNR Land Reclamation Program (LRP) has been supplementing USGS sampling with the following parameters: acidity, alkalinity, conductivity, iron, pH, settleable solids and sulfate. LRP has been sampling at approximately two-month intervals at multiple sites within the project limits and downstream. MDNR Water Pollution Control Program (WPCP) will continue low flow water chemistry monitoring of Cedar Creek annually from now until at least through the year 2004.

9. Implementation Plans

An MDNR reclamation project focusing on a few major acid seeps in the Upper Cedar Creek AML area was begun in the fall of 2000 and should be completed by 2001 or 2002. The anaerobic wetland-alkalinity producing systems to be installed have been designed to allow acidic, iron-and sulfate-rich water to seep through an organic substrate and underlying bed of crushed limestone. The primary function of the organic matter is to consume dissolved oxygen and convert iron and manganese already in solution to reduced forms. These reactions are necessary so that the limestone gravel does not become coated with metal precipitates that would impair its ability to generate alkalinity. Sulfate reduction is an important secondary benefit of the organic matter. The life of these wetlands and the organic/limestone/ag-lime cells is calculated to be 20 years. A copy of the project, complete with blueprints, and other references apropos to the project are on file with MDNR's WPCP and LRP offices. Post-implementation monitoring will determine the success of the reclamation project. If this monitoring shows that acidity (low pH) or elevated sulfate problems still persist in Cedar Creek, additional treatment needs will be assessed. This TMDL will be incorporated into Missouri's Water Quality Management Plan.

10. Reasonable Assurances

The Water Pollution Control Program will issue a stormwater permit to the Land Reclamation Program for the mined land area. This will remain in force as long as the mined land is a source of water contaminants related to the permitted construction activities. The permit will require water quality monitoring of Cedar Creek monthly during construction and every two to three months after construction for at least one year. The WPCP will continue low flow water chemistry monitoring of Cedar Creek annually from now until at least through the year 2004. If this monitoring reveals that water quality standards are not being met for pH (6.5 to 9.0 SU) or sulfate plus chloride (900 mg/L or less), or the numeric target is not being met for net alkalinity (60 mg/L or more), then these TMDLs will be re-opened and re-evaluated. Periodic review of MDNR's Water Quality Management Plans and monitoring data by EPA and MDNR should provide reasonable assurance that plan objectives are met.

11. Public Participation

This water quality limited segment of Cedar Creek is included on the approved 1998 303(d) list for Missouri. The TMDL was developed by the Missouri Department of Natural Resources, Division of Environmental Quality, Water Pollution Control Program. Six public meetings to allow input from the public on impaired waters were held between Aug. 18 and Sept. 22, 1999. No comments pertaining to Cedar Creek were received during the public meetings. A public notice period for the draft TMDL was held from Nov. 10 to Dec. 10, 2000. Groups receiving the public notice announcement included the Missouri Clean Water Commission, the affected facility, the Water Quality Coordinating Committee, the TMDL Advisory Committee, Stream Team volunteers in the watershed and others that routinely receive the public notice of NPDES permits. Comments were received from Missouri Department of Conservation and Sierra Club. No adjustments to the TMDL document were suggested. Copies of the notice, the comments and MDNR's response to the comments are on file with MDNR.

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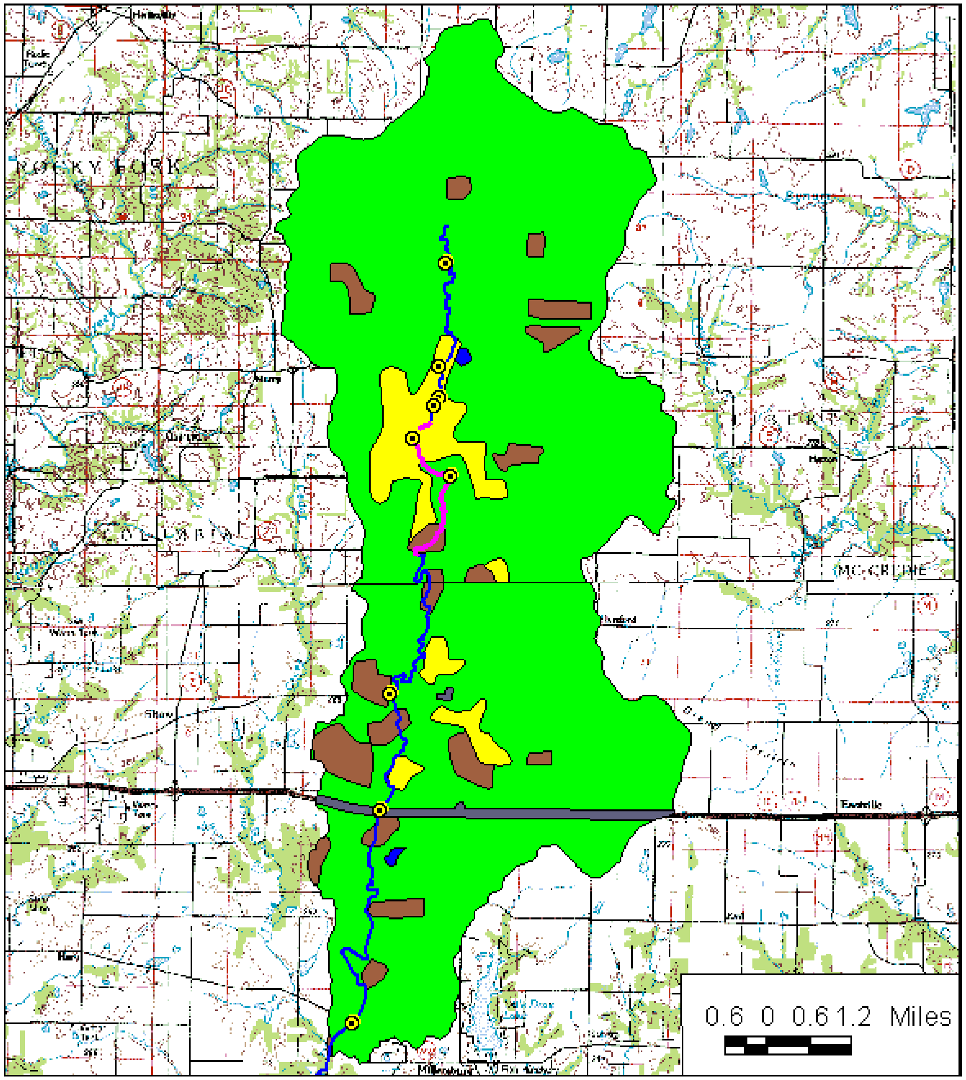
12. Appendices and List of Documents on File with MDNR

Appendix A - Use map for Cedar Creek watershed
Appendix B – Topographic map showing sampling sites and impaired segment
Appendix C – Pre- and Post-reclamation data and summary of 1981-82 studies

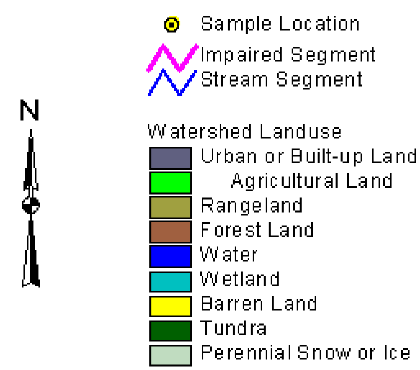
Documents on file with MDNR:

Proposal and Quality Assurance Project Plan for Assessment of the Biological Recovery of the Upper Cedar Creek, Boone County, Missouri, Following an Abandoned Mine-Land Reclamation (USGS)
Upper Cedar Creek Project-A Grant Proposal by Missouri Department of Natural Resources, Land Reclamation Program, Abandoned Mine Lands Section
Upper Cedar Creek OLA Cells
Upper Cedar Creek Project Field Tour Notes, Aug. 31, 1999
A Handbook of Constructed Wetlands, Volume 4: Coal Mine Drainage
Identification and Evaluation of Acid Mine Drainage in the Cedar Creek Watershed, Report VIII, Project Report [1981-1982]
Public notice announcement
Public comments
MDNR’s response to public comments

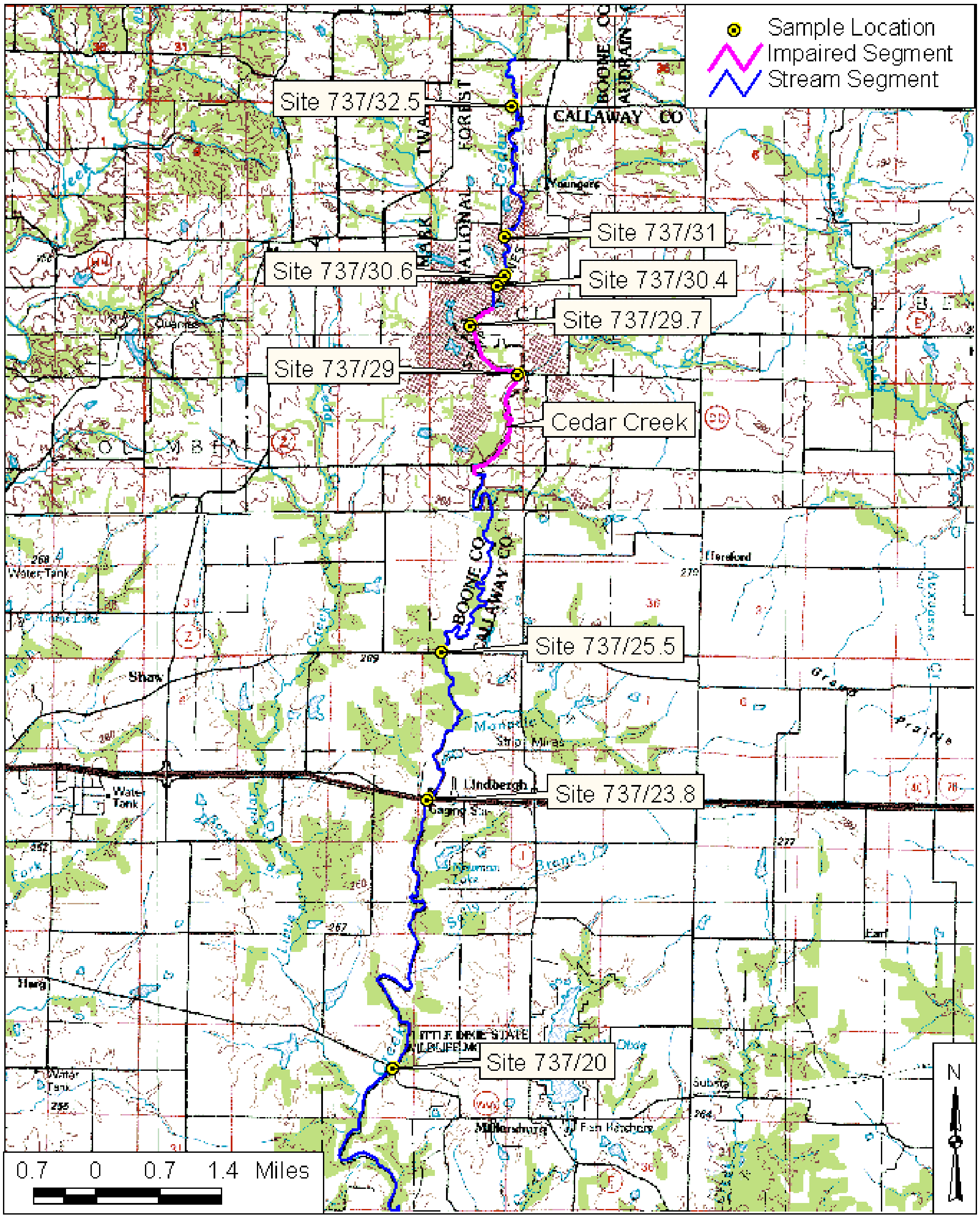
Appendix A. Land Use Types for Cedar Creek Watershed (10300102-190001)



Land Use Type		Area (acres)
Urban or Built-up Land		424
Trans, Comm, Util	408	
Mixed Urban or Built-up	16	
Agricultural Land		28929
Cropland and Pasture	28929	
Forest Land		2031
Deciduous Forest Land	2031	
Water		49
Reservoirs	49	
Barren Land		1877
Strip Mines	1877	



Appendix B. Map of Sample Locations and Impaired Stream Segment
Cedar Creek, Callaway County, Missouri



Appendix C

Cedar Creek Pre-reclamation Data

Flow is in cfs; pH=pH in SU; Alk=Alkalinity in mg/L; Acid=Acidity in mg/L; SO4=Sulfate in mg/L; CL=Chloride in mg/L; SC=Specific Conductivity in µS/cm

Site	Site Name	Yr	Mo	Dy	WBID	Flow	pH	Alk	Acid	SO4	Cl	SC
ENV0737/20	Cedar Cr. 4.8 mi.bl. Manacle Cr.	1981	7	31	737	25.8	6.9	18	0	296		
ENV0737/20	Cedar Cr. 4.8 mi.bl. Manacle Cr.	1981	8	27	737	8.4	6.5	4.2	11.8	750		
ENV0737/20	Cedar Cr. 4.8 mi.bl. Manacle Cr.	1981	9	28	737	0.4	5.6	37	0	602		
ENV0737/20	Cedar Cr. 4.8 mi.bl. Manacle Cr.	1981	10	27	737	1.9	5.1	0	96	876		
ENV0737/20	Cedar Cr. 4.8 mi.bl. Manacle Cr.	1981	11	22	737	4.78	5.9	16	0	576		
ENV0737/20	Cedar Cr. 4.8 mi.bl. Manacle Cr.	1981	12	28	737	3.5	5.7	4	38	758		
ENV0737/20	Cedar Cr. 4.8 mi.bl. Manacle Cr.	1982	1	25	737	0.0099	7.1	28	10	156		
ENV0737/20	Cedar Cr. 4.8 mi.bl. Manacle Cr.	1982	2	24	737	82.9	6.5	22	18	189		
ENV0737/20	Cedar Cr. 4.8 mi.bl. Manacle Cr.	1982	3	24	737	19.46	6.1	27	0	286		
ENV0737/20	Cedar Cr. 4.8 mi.bl. Manacle Cr.	1982	4	27	737	7	7.1	24	0	555		
ENV0737/20	Cedar Cr. 4.8 mi.bl. Manacle Cr.	1982	5	24	737	25.2	6.8	60	0	340		
ENV0737/20	Cedar Cr. 4.8 mi.bl. Manacle Cr.	1982	6	21	737	9.4	5.5	12	39	200		
ENV0737/23.8	Cedar Cr. 1 mi.bl. Manacle Cr.	1981	7	30	737	34	6.7	14	20	316		
ENV0737/23.8	Cedar Cr. 1 mi.bl. Manacle Cr.	1981	8	27	737	6.5	4.4	0	53.8	746		
ENV0737/23.8	Cedar Cr. 1 mi.bl. Manacle Cr.	1981	9	28	737	0.0099	3.8	0	63	1867		
ENV0737/23.8	Cedar Cr. 1 mi.bl. Manacle Cr.	1981	10	26	737	1.04	3.7	0	122	1148		
ENV0737/23.8	Cedar Cr. 1 mi.bl. Manacle Cr.	1981	11	22	737	3.11	4.6	0	99	770		
ENV0737/23.8	Cedar Cr. 1 mi.bl. Manacle Cr.	1981	12	28	737	3.2	4.3	0	190	1140		
ENV0737/23.8	Cedar Cr. 1 mi.bl. Manacle Cr.	1982	1	25	737	0.0099	6	26	8	193		
ENV0737/23.8	Cedar Cr. 1 mi.bl. Manacle Cr.	1982	2	24	737	68.3	6.4	16	36	194		
ENV0737/23.8	Cedar Cr. 1 mi.bl. Manacle Cr.	1982	3	24	737	15.7	6.7	15	16	389		
ENV0737/23.8	Cedar Cr. 1 mi.bl. Manacle Cr.	1982	4	27	737	5.1	4.6	8	92	740		
ENV0737/23.8	Cedar Cr. 1 mi.bl. Manacle Cr.	1982	5	24	737	11.6	5.5	18	5	375		
ENV0737/23.8	Cedar Cr. 1 mi.bl. Manacle Cr.	1982	6	21	737	0.0099	4.2	2	62	250		
ENV0737/25.5	Cedar Cr. 3.5 mi.bl. Cedar Cr. AML area	1981	7	30	737	34.9	6.8	22	20	300		
ENV0737/25.5	Cedar Cr. 3.5 mi.bl. Cedar Cr. AML area	1981	8	27	737	10.4	6.1	0	13.4	519		
ENV0737/25.5	Cedar Cr. 3.5 mi.bl. Cedar Cr. AML area	1981	9	28	737	0.0099	4.5	0	44	789		
ENV0737/25.5	Cedar Cr. 3.5 mi.bl. Cedar Cr. AML area	1981	10	26	737	0.2	3.9	0	140	1027		
ENV0737/25.5	Cedar Cr. 3.5 mi.bl. Cedar Cr. AML area	1981	11	22	737	1	3.9	0	40	475		
ENV0737/25.5	Cedar Cr. 3.5 mi.bl. Cedar Cr. AML area	1981	12	28	737	2.7	4.5	0	70	778.6		
ENV0737/25.5	Cedar Cr. 3.5 mi.bl. Cedar Cr. AML area	1982	1	25	737	13.9	7	26	24	147		
ENV0737/25.5	Cedar Cr. 3.5 mi.bl. Cedar Cr. AML area	1982	2	24	737	40	6.6	28	12	153		
ENV0737/25.5	Cedar Cr. 3.5 mi.bl. Cedar Cr. AML area	1982	3	24	737	11.4	6	48	0	281		
ENV0737/25.5	Cedar Cr. 3.5 mi.bl. Cedar Cr. AML area	1982	4	27	737	0.0099	6.5	14	0	490		
ENV0737/25.5	Cedar Cr. 3.5 mi.bl. Cedar Cr. AML area	1982	5	24	737	11.8	6.5	56	0	235		
ENV0737/25.5	Cedar Cr. 3.5 mi.bl. Cedar Cr. AML area	1982	6	21	737	15.56	4.4	0	89	415		
ENV0737/28.9	Cedar Cr. @ S.end of Cedar Cr. AML area	1981	7	30	737	20.8	5.7	20	24	275		
ENV0737/28.9	Cedar Cr. @ S.end of Cedar Cr. AML area	1981	8	27	737	5.68	5.6	22.	0	482		
ENV0737/28.9	Cedar Cr. @ S.end of Cedar Cr. AML area	1981	9	28	737	0.0099	5.5	0	108	1083		
ENV0737/28.9	Cedar Cr. @ S.end of Cedar Cr. AML area	1981	10	26	737	0.43	3.8	0	184	1353		
ENV0737/28.9	Cedar Cr. @ S.end of Cedar Cr. AML area	1981	11	22	737	1.3	4.8	0	130	615		
ENV0737/28.9	Cedar Cr. @ S.end of Cedar Cr. AML area	1981	12	28	737	2	5.8	6	68	710.2		
ENV0737/28.9	Cedar Cr. @ S.end of Cedar Cr. AML area	1982	1	25	737	9	6.5	28	12	146		
ENV0737/28.9	Cedar Cr. @ S.end of Cedar Cr. AML area	1982	2	24	737	39.2	6.5	32	4	105		

ENV0737/28.9	Cedar Cr. @ S.end of Cedar Cr. AML area	1982	3	24	737	10.1	6	34	18	293		
ENV0737/28.9	Cedar Cr. @ S.end of Cedar Cr. AML area	1982	4	27	737	1.6	6.7	32	0	475		
ENV0737/28.9	Cedar Cr. @ S.end of Cedar Cr. AML area	1982	5	24	737	8.8	6.3	48	0	274		
ENV0737/28.9	Cedar Cr. @ S.end of Cedar Cr. AML area	1982	6	21	737	5.8	6	19	33	290		
ENV0737/29	Cedar Cr. within Cedar Cr. AML area	1981	7	30	737	16.2	6	28	12	196		
ENV0737/29	Cedar Cr. within Cedar Cr. AML area	1981	8	27	737	4.85	6.1	40	0	414		
ENV0737/29	Cedar Cr. within Cedar Cr. AML area	1981	10	26	737	0.17	4	0	132	1129		
ENV0737/29	Cedar Cr. within Cedar Cr. AML area	1981	11	22	737	0.87	5.7	6	100	527		
ENV0737/29	Cedar Cr. within Cedar Cr. AML area	1981	12	28	737	0.0099	6.2	14	30	611.5		
ENV0737/29	Cedar Cr. within Cedar Cr. AML area	1982	1	25	737	9	6.9	24	46	130		
ENV0737/29	Cedar Cr. within Cedar Cr. AML area	1982	2	24	737	34.6	6.5	32	0	130		
ENV0737/29	Cedar Cr. within Cedar Cr. AML area	1982	3	24	737	9.36	5.9	40	0	240		
ENV0737/29	Cedar Cr. within Cedar Cr. AML area	1982	4	27	737	1.4	6.9	42	0	355		
ENV0737/29	Cedar Cr. within Cedar Cr. AML area	1982	5	24	737	7.7	6.4	56	0	212		
ENV0737/29	Cedar Cr. within Cedar Cr. AML area	1982	6	21	737	5.45	6.4	22	15	255		
ENV0737/29.4	Cedar Cr. within Cedar Cr. AML area	1981	7	30	737	12.6	6.3	52	8	148		
ENV0737/29.4	Cedar Cr. within Cedar Cr. AML area	1981	8	27	737	3.17	7.3	49.	0	403		
ENV0737/29.4	Cedar Cr. within Cedar Cr. AML area	1981	9	28	737	0	6.9	8	26	668		
ENV0737/29.4	Cedar Cr. within Cedar Cr. AML area	1981	10	26	737	1	6.4	4	90	830		
ENV0737/29.4	Cedar Cr. within Cedar Cr. AML area	1981	11	22	737	0.75	6.9	40	0	290		
ENV0737/29.4	Cedar Cr. within Cedar Cr. AML area	1981	12	28	737	1.9	7.6	66	10	417.3		
ENV0737/29.4	Cedar Cr. within Cedar Cr. AML area	1982	1	25	737	5	5.9	28	30	97.1		
ENV0737/29.4	Cedar Cr. within Cedar Cr. AML area	1982	2	24	737	30.7	6.6	38	0	124		
ENV0737/29.4	Cedar Cr. within Cedar Cr. AML area	1982	3	24	737	7.29	6.9	58	0	172		
ENV0737/29.4	Cedar Cr. within Cedar Cr. AML area	1982	4	27	737	1.1	7.5	60	0	127		
ENV0737/29.4	Cedar Cr. within Cedar Cr. AML area	1982	5	24	737	6.4	6.9	116	0	125		
ENV0737/29.4	Cedar Cr. within Cedar Cr. AML area	1982	6	21	737	5.22	6.7	50	32	200		
ENV0737/30.5	Cedar Cr. @ N.end of Cedar Cr. AML area	1981	7	30	737	12.2	6.3	68	8	61		
ENV0737/30.5	Cedar Cr. @ N.end of Cedar Cr. AML area	1981	8	27	737	1.71	6.8	82.	0	136		
ENV0737/30.5	Cedar Cr. @ N.end of Cedar Cr. AML area	1981	9	28	737	0	7.3	97	0	244		
ENV0737/30.5	Cedar Cr. @ N.end of Cedar Cr. AML area	1981	10	26	737	0.8	7.1	60	0	332		
ENV0737/30.5	Cedar Cr. @ N.end of Cedar Cr. AML area	1981	11	22	737	0.1	7	64	0	128		
ENV0737/30.5	Cedar Cr. @ N.end of Cedar Cr. AML area	1981	12	28	737	0.8	7.5	78	4	239.5		
ENV0737/30.5	Cedar Cr. @ N.end of Cedar Cr. AML area	1982	1	25	737	4	7	26	27	35.4		
ENV0737/30.5	Cedar Cr. @ N.end of Cedar Cr. AML area	1982	2	24	737	25.2	6.8	42	0	63		
ENV0737/30.5	Cedar Cr. @ N.end of Cedar Cr. AML area	1982	3	24	737	4.85	6.8	88	0	86		
ENV0737/30.5	Cedar Cr. @ N.end of Cedar Cr. AML area	1982	4	27	737	0.5	7.4	78	0	170		
ENV0737/30.5	Cedar Cr. @ N.end of Cedar Cr. AML area	1982	5	24	737	6.5	7	118	0	55		
ENV0737/30.5	Cedar Cr. @ N.end of Cedar Cr. AML area	1982	6	21	737	2.83	6.9	58	0	105		
ENV0737/31	Cedar Cr. 0.5 mi.ab. Cedar Cr. AML area	1981	7	30	737	13.3	5.5	70	10	62		
ENV0737/31	Cedar Cr. 0.5 mi.ab. Cedar Cr. AML area	1981	8	27	737	0.67	6.9	91.	0	162		
ENV0737/31	Cedar Cr. 0.5 mi.ab. Cedar Cr. AML area	1981	9	28	737	0.0099	7.1	122	0	282		
ENV0737/31	Cedar Cr. 0.5 mi.ab. Cedar Cr. AML area	1981	10	26	737	0.0099	6.7	106	0	264		
ENV0737/31	Cedar Cr. 0.5 mi.ab. Cedar Cr. AML area	1981	11	22	737	0.4	6.9	70	0	161		
ENV0737/31	Cedar Cr. 0.5 mi.ab. Cedar Cr. AML area	1981	12	28	737	0.0099	7.9	82	16	201.6		
ENV0737/31	Cedar Cr. 0.5 mi.ab. Cedar Cr. AML area	1982	1	25	737	3.5	6.9	25	11.4	37		
ENV0737/31	Cedar Cr. 0.5 mi.ab. Cedar Cr. AML area	1982	2	24	737	19	6.8	42	0	59		
ENV0737/31	Cedar Cr. 0.5 mi.ab. Cedar Cr. AML area	1982	3	24	737	4.2	6.9	66	0	70		
ENV0737/31	Cedar Cr. 0.5 mi.ab. Cedar Cr. AML area	1982	4	27	737	0.6	7.7	84	0	127		
ENV0737/31	Cedar Cr. 0.5 mi.ab. Cedar Cr. AML area	1982	5	24	737	4.1	7.1	122	0	50		
ENV0737/31	Cedar Cr. 0.5 mi.ab. Cedar Cr. AML area	1982	6	21	737	2.31	7.4	61	0	75		
ENV0737/32.5	Cedar Cr. 2 mi.ab. Cedar Cr. AML area	1981	7	30	737	1.12	6.1	96	10	22		
ENV0737/32.5	Cedar Cr. 2 mi.ab. Cedar Cr. AML area	1981	8	27	737	0.5	5.5	32.	0	26		

ENV0737/32.5	Cedar Cr. 2 mi.ab. Cedar Cr. AML area	1981	9	28	737	0	6.8	128	0	94		
ENV0737/32.5	Cedar Cr. 2 mi.ab. Cedar Cr. AML area	1981	10	26	737	0	5.9	104	16	45		
ENV0737/32.5	Cedar Cr. 2 mi.ab. Cedar Cr. AML area	1981	11	22	737	0.0099	6.4	72	0	54		
ENV0737/32.5	Cedar Cr. 2 mi.ab. Cedar Cr. AML area	1981	12	28	737	0.0099	7.4	98	58	46.9		
ENV0737/32.5	Cedar Cr. 2 mi.ab. Cedar Cr. AML area	1982	1	25	737	0.9	5.5	53	0	39.5		
ENV0737/32.5	Cedar Cr. 2 mi.ab. Cedar Cr. AML area	1982	2	24	737	5.4	6.8	60	0	39		
ENV0737/32.5	Cedar Cr. 2 mi.ab. Cedar Cr. AML area	1982	3	24	737	1.3	6.8	80	0	35		
ENV0737/32.5	Cedar Cr. 2 mi.ab. Cedar Cr. AML area	1982	4	27	737	0.1	7.4	100	0	3		
ENV0737/32.5	Cedar Cr. 2 mi.ab. Cedar Cr. AML area	1982	5	24	737	0.2	6.9	196	0	27		
ENV0737/32.5	Cedar Cr. 2 mi.ab. Cedar Cr. AML area	1982	6	21	737	0.61	6.6	78	0	23		

Cedar Creek Post-reclamation Data

Site	Site Name	Yr	Mo	Dy	WBID	Flow	pH	Alk	Acid	SO4	Cl	SC
MDNR0737/29	Cedar Cr. @ S.end of Cedar Cr. AML area	2000	3	30	737		6.9	74		486	9	900
MDNR0737/29	Cedar Cr. @ S.end of Cedar Cr. AML area	1998	7	21	737		7.2	66	0	457		960
MDNR0737/29	Cedar Cr. @ S.end of Cedar Cr. AML area	1998	8	6	737		7.2	64	0	149		450
MDNR0737/29	Cedar Cr. @ S.end of Cedar Cr. AML area	1998	9	9	737		6.5	18	0	911		1570
MDNR0737/29	Cedar Cr. @ S.end of Cedar Cr. AML area	1997	10		737		4.5					2450
MDNR0737/29	Cedar Cr. @ S.end of Cedar Cr. AML area	1997	9		737	0.02	4.4					1875
MDNR0737/29	Cedar Cr. @ S.end of Cedar Cr. AML area	1995	12		737		4.5					2450
MDNR0737/29	Cedar Cr. @ S.end of Cedar Cr. AML area	2000	4	25	737		7.2	37	0	976	11	1350
MDNR0737/27.8	Cedar Cr. 1.2 mi.bl. Cedar Cr. AML area	2000	3	30	737		7.4	66		461	9	800
MDNR0737/27.8	Cedar Cr. 1.2 mi.bl. Cedar Cr. AML area	1997	7		737	6	7					757
MDNR0737/27.8	Cedar Cr. 1.2 mi.bl. Cedar Cr. AML area	2000	4	25	737		7.4	61	0	703	13	1080
MDNR0737/25.5	Cedar Cr. 3.5 mi.bl. Cedar Cr. AML area	2000	4	25	737		7.6	43	0	661	9	980
MDNR0737/25.5	Cedar Cr. 3.5 mi.bl. Cedar Cr. AML area	1998	4	20	737	3	7.2					547
MDNR0737/25.5	Cedar Cr. 3.5 mi.bl. Cedar Cr. AML area	1998	7	21	737		7.3	68	0	295		705
MDNR0737/25.5	Cedar Cr. 3.5 mi.bl. Cedar Cr. AML area	1998	8	6	737		7.2	60	0	179		500
MDNR0737/25.5	Cedar Cr. 3.5 mi.bl. Cedar Cr. AML area	1998	9	9	737		6.8	72	0	300		780
MDNR0737/25.5	Cedar Cr. 3.5 mi.bl. Cedar Cr. AML area	1997	10		737	0.1	6.4					1143
MDNR0737/25.5	Cedar Cr. 3.5 mi.bl. Cedar Cr. AML area	1992	3		737	1.5	6.8					790
MDNR0737/25.5	Cedar Cr. 3.5 mi.bl. Cedar Cr. AML area	1992	7		737	6	7.1					638
MDNR0737/25.5	Cedar Cr. 3.5 mi.bl. Cedar Cr. AML area	1995	12		737	0.5	6.3					1710
MDNR0737/20	Cedar Cr. 4.8 mi.bl. Manacle Cr.	2000	3	30	737		7.7	60		210	15	490
MDNR0737/20	Cedar Cr. 4.8 mi.bl. Manacle Cr.	2000	4	25	737		8	113	0	300	19	740
MDNR0737/20	Cedar Cr. 4.8 mi.bl. Manacle Cr.	1998	4	20	737	5	7.5	87	0	194		515
MDNR0737/20	Cedar Cr. 4.8 mi.bl. Manacle Cr.	1998	7	21	737		7.6	68	0	128		560
MDNR0737/20	Cedar Cr. 4.8 mi.bl. Manacle Cr.	1998	8	6	737		7.5	121	0	148		440
MDNR0737/20	Cedar Cr. 4.8 mi.bl. Manacle Cr.	1998	9	9	737							770
MDNR0737/20	Cedar Cr. 4.8 mi.bl. Manacle Cr.	1997	7		737	8	7					592
MDNR0737/29.7	Cedar Cr. within Cedar Cr. AML area	1998	4	20	737	2.5	6.9					615
MDNR0737/29.7	Cedar Cr. within Cedar Cr. AML area	1999	8	31	737	0	3.3					7330
MDNR0737/30.6	Cedar Cr. @ N.end of Cedar Cr. AML area	2000	3	30	737		8	103		256	12	630
MDNR0737/30.6	Cedar Cr. @ N.end of Cedar Cr. AML area	1999	8	31	737	0	6.8					2370
MDNR0737/30.6	Cedar Cr. @ N.end of Cedar Cr. AML area	2000	4	25	737		8	125	0	217	13	610
MDNR0737/30.4	Cedar Cr. just ab. Cedar Cr. AML area	1998	7	21	737		7.3		103	98		450
MDNR0737/30.4	Cedar Cr. just ab. Cedar Cr. AML area	1998	6	8	737				0	38	79	270
MDNR0737/30.4	Cedar Cr. just ab. Cedar Cr. AML area	1998	9	9	737		6.4	112	0	112		470
MDNR0737/30.4	Cedar Cr. just ab. Cedar Cr. AML area	1998	8	31	737	0						700

The above pre-reclamation data was condensed from the "Identification and Evaluation of Acid Mine Drainage in the Cedar Creek Watershed, Report VIII, Project Report", which is on file at the Missouri Department of Natural Resources' (MDNR) Water Pollution Control Program. Envirodyne Engineers, Inc., of St. Louis, prepared this 160-page report for MDNR's Land Reclamation Commission in January 1983. The introduction appears below:

> This report is intended to draw together all information gathered during the course of the project that was of significant value in the final prioritization of abandoned mine lands in the Cedar Creek watershed. It is intended to provide a single reference volume that presents, in a summarized manner, the results of major investigative tasks and the final prioritization ranking system used.
>
> Report VII, Water Pollution and Pollution Source Evaluation Report, is included in its entirety with minor revisions to clarify the methodology used on priority ranking. This report contains the final prioritization for reclamation on the abandoned mine lands studied and as such is the culmination of the project.
>
> Report VI, Water Monitoring Data Evaluation Report, is also included in its entirety because the water quality data and its evaluation was the primary data set utilized in the mined lands evaluation. It is felt that the data presented in this report provides a singularly important base necessary for evaluation of the validity of the prioritization presented in Report VII.
>
> Report V, Soil Survey Summary Report, has been included in a condensed form that presents data gathered during the soil survey in a summarized manner. It was felt that the raw data contained in the original soils report was not necessary and that by providing data summaries for each mined land segment, the value of the soils investigation to the final project report could be enhanced.
>
> Report II, Acidic Impoundment Survey Report, has also been included in a condensed form. It was felt that water quality data for individual impoundments would be excessive and that the data summaries for each mined land segment would adequately represent the significant findings of the impoundment survey.
>
> No portions of Reports I, III, or IV have been included in this final project report. Report I, which included a summary of existing data and the results of reconnaissance water quality survey, was omitted for two reasons. The existing data was primarily the result of a single USGS gaging station in Cedar Creek and as such did not present a comprehensive picture of water quality in the watershed. Water quality data from the reconnaissance survey was not included because it was felt that its value was superseded by the acidic impoundment survey results presented in Report II. Report III was a series of monthly progress reports prepared during the year-long monitoring program. These reports have been summarized and all data presented in the final Water Monitoring Data Evaluation to be used in the soil sampling program and has essentially been included as a portion of Chapter 1 of the Soil Survey Summary Report (V).